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An Evaluation of Computer Assisted Learning in the Workplace

J. Brouard

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NOTE

In this document, the masculine is used without discrimination and solely with a view to shortening the text.

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ABSTRACT

Computer assisted learning (CAL) as applied to training in the workplace offers a number of educational and logistical advantages. Little information is available on CAL applications in Canadian companies and organizations. In cooperation with the Institut national de la recherche scientifique en éducation (INRS-Education, Québec), the National Research Council of Canada (NRCC, Ottawa) has undertaken a study of the applications and implications of CAL in the workplace, specifically at NRCC. This report discusses conditions and results of the project's preliminary phase, conducted from April 3 to July 24, 1985, in the NRCC Information Science Section (Division of Electrical Engineering). Seven NRCC employees participated. All considered the training an enriching experience, and would support the introduction of CAL systems in the workplace.

AN EVALUATION OF COMPUTER ASSISTED LEARNING IN THE WORKPLACE

J. Brouard

1. INTRODUCTION

1.1 Computer Assisted Learning and Training in the Workplace

The adoption of new technology by industries and scientific organizations anxious to keep up in a competitive economy has created a serious need for technical training and upgrading of existing skills (1). Employees in a great variety of organizations and companies are increasingly required to use new technology in their work, and they have to acquire the relevant skills and knowledge.

Training in the workplace presents a number of major problems, both logistical and educational (2). One of the most serious problems stems from the fact that the employees eligible for a training program are often spread throughout an entire region, or even the entire country. Taking a course often involves travelling long distances and being absent from work for long periods of time, which can seriously interfere with an employee's work.

Adult student motivation is usually directed toward upgrading an existing skill or acquiring a new and useful technique. To an adult, learning is a means to an end, not an end in itself (3). The usual aim of an adult student is mastery of the technique or skill in question, which may be unrealistic in the context of a class environment that stresses group learning.

The relatively great need for improved and readily accessible training in the workplace is compatible with the computer's potential for effective training in situations where teaching is not a fundamental objective of the organization. Computers are known for their ability to meet a variety of needs related to training in the workplace. Past and present experience demonstrates the advantages and benefits of computer assisted learning (CAL) (2, 4-7).

Personalized instruction means greater flexibility in course timetables and considerably lower training costs. Courses may be offered in the employee's workplace. The timetable may be adjusted to suit each individual's working hours. There are none of the restrictions implied by a fixed timetable or a minimum number of participants.

CAL's combination of flexible timetable and personalized instruction makes it possible for each student to progress at his own speed, building on prior knowledge of the subject.

The computer's unlimited patience allows the student to review material as required and to practise and perform additional exercises under a variety of conditions. CAL is different from all other instructional media in that the user-medium interaction implicit in a CAL situation makes the individual an active participant, who is personally involved in the learning process.

One of the most important educational advantages of CAL is the ability of the medium to simulate equipment, situations (or cases), complex processes or operations carried out in a specific sequence.

More and more employees are using computers as a matter of course. According to Friedman (8), this means that for those employees who work at a computer terminal, the terminal is a natural and desirable training environment.

1.2 The Need for Assessment Studies

CAL offers many advantages to all organizations and companies that have technical training and skill upgrading requirements. Schwade (2) emphasizes that, because the advantages of CAL are situation specific, they cannot be expressed in absolute terms.

The actual assistance provided by the computer varies with the employee, the nature of his work, his requirements, the organizational structure, and the effectiveness of existing traditional training systems, if any.

There is a need for studies that assess the actual and potential contribution of the computer to training in the workplace. Describing practical CAL applications can pinpoint factors that must be considered in designing future applications. Assessment studies encourage the introduction of CAL and demonstrate the computer's effectiveness for training purposes. To date, relatively little information is available on CAL projects in Canadian companies and organizations.

1.3 NRCC Assessment Project

With all this in mind, the National Research Council of Canada (NRCC, Ottawa), in cooperation with l'Institut national de la recherche scientifique en éducation (INRS-Education, Québec), undertook an assessment project involving a study of the applications and implications of CAL in

the workplace, using NRCC as a concrete example. The project was carried out in the Information Science Section of the Division of Electrical Engineering.

The National Research Council, like most workplaces, has no well-defined teaching structures, and there are no specific training programs of any kind. The introduction of a CAL training system is therefore doubly innovative.

The project primarily provided employees with an opportunity to take a computer assisted course that would provide them with relevant skills. A course on digital computers was selected for the trial period covered by this report from April 3 to July 24, 1985. Seven NRCC employees took part.

The purpose of the study was to provide an answer to the question, "Can computer assisted learning make a significant and valuable contribution to the training of NRCC employees?" The answer lies in studying a practical application of a CAL system in the workplace, and its potential value to employees.

What is assessed is the use in context, i.e., the conditions under which the computer assisted course is used, rather than the course itself. Obviously the nature and quality of a computer assisted course is inextricably linked to the course's impact and results. While recognizing that this is the case, the study attempts to assess the fundamentals of CAL itself.

1.4 Report Aim and Content

The report's main objective is to provide relevant information on which the reader can build a relatively accurate idea of project procedure and results. The reader who is interested in CAL applications in the workplace in general can assess the value or relevance of the project, and form an opinion on the appropriate measures to be taken.

Section 2 describes the context, i.e., conditions and procedures specific to the situation (course used, participants, procedure followed). The section also describes the techniques and instruments used to gather quantitative and qualitative data in terms of when each was used.

The third section deals mainly with how the experiment was seen by the participating employees. Participant comments and observations indicate the degree of satisfaction with skills acquired and course relevance, and provide insight into CAL benefits and drawbacks.

2. CONDITIONS AND PROCEDURES

2.1 Computer Assisted Learning Course Used

The course selected for the trial period is called DIGITAL COMPUTER FUNDAMENTALS. It was designed and developed at the Department of National Defence for training the Department's computer maintenance technicians.

The introductory course is designed to help employees acquire the skills related to digital computer functional units, programming, and peripherals in general. The following is a summary of course objectives, defined in terms of expected results.

The student will be able to

- describe basic operations and uses of analog and digital computers
- identify basic logic circuits and corresponding truth tables
- describe operation and use of buses
- describe operation of control unit and arithmetic and logical unit (ALU)
- solve problems related to different types of numerical system conversion, and to computer arithmetic
- identify fundamental principles of digital computer circuit systems
- identify types and functions of computer memory
- identify different bus structures
- do digital microcomputer troubleshooting
- be familiar with the fundamentals of microcomputer programming
- identify and describe the uses of peripheral equipment

As shown in the Table of Contents in Appendix A, the course is divided into seven chapters and subdivided into lessons. A test is given at the end of each lesson and at the end of each chapter. The student must obtain at least 70% before going on to the next lesson or chapter.

The course requires a LEKTROMEDIA terminal incorporating a direct access 35 mm slide projector system. The screens of both projector and video display are touch controlled. The student responds by touching the screen, or activates equipment simulation by touching an illustration (Fig. 1). Two

terminals were available to students. They were located in the Information Science Section, in a room specially set up as a classroom. The equipment was connected to a DATA GENERAL MV8000 minicomputer, operated on a time-sharing basis (central system).

At a number of intervals throughout the course, the students were given a practical lab related to the subject matter displayed on the terminal. The equipment used was a HEWLETT-PACKARD portable mini-lab based on a computer microprocessor (Fig. 2). The equipment was supplied with a lab manual, but only one copy of the manual was available.

The main reason for selecting this particular course was its obvious suitability for giving a large number of NRCC laboratory employees an opportunity to acquire new knowledge or upgrade existing skills. Because of the increase in computer use in the workplace, it was felt that the knowledge and skills the course would provide would be extremely useful. Furthermore, the Section where the project was conducted had on-site computer support and better than average familiarity with course content and computer programming.

Before the employees began any training, Information Science Section technicians tested the course. At their suggestion, a few changes were made to tailor the course to the participants. The original program was written in NATAL II; the adaptation is written in microNATAL.

2.2 Selection of Participants

Participants were selected on the basis of answers to a letter of invitation sent by the Director of the Division of Electrical Engineering to the directors of all Ottawa-based scientific divisions, each of which has a number of sections. The total number of technical and scientific staff employed in the divisions is approximately 1300.

Figure 1. Equipment required: LEKTROMEDIA multi-media terminal

Figure 2. Equipment required: Hewlett-Packard Mini-lab

The letter of invitation briefly described the assessment project and asked for the names of employees likely to benefit from the course and willing to devote some one hundred hours of working time to the project over a three-month period (April, May, and June 1985). Appendix B contains a copy of the letter and a list of the divisions to which it was sent. The letter was distributed internally and copies were posted on employee notice boards.

During the three weeks after the letter was sent, nearly 30 employees expressed interest in the course. All wished to register for the current session, or for a subsequent one if the timing was inconvenient. Most employees, with the permission of their immediate supervisor, contacted us directly. A few supervisors requested additional information on organizational procedures and expressed a desire to register one or more employees because of the subject matter's relevance.

Because approximate course length was estimated at 100 h, and because only two terminals were available (reserved exclusively for the project), it was decided that the first series of trials would enroll a maximum of eight students. The first eight employees who said they were available in April were selected. In a way, the participants did the selection. In addition to course length and number of terminals available, the factors that had the greatest impact on employee participation were: employee interest in subject matter, employee availability, employee agreement to participate in the assessment procedure, and permission of employee's immediate supervisor for him to be absent from work for a specific number of hours per week over a period of two or three months.

One of the eight employees who began the course was forced to quit after several weeks because of time restrictions and an unexpected workload. His departure had nothing to do with the quality or relevance of the course. Furthermore, all the employees who had contacted us - including the one who had to quit - expressed interest in following a course in the future. They will have the opportunity to do so because further sessions are planned. Other courses may be offered, and additional terminals may be installed in some divisions.

2.3 Preliminary Meeting

A preliminary meeting was held with the person responsible for the project and each course participant to discuss the project and the assessment method to be used. Each employee was asked to fill in a questionnaire (Appendix C) on a variety of factors: division, section, job description, familiarity with subject matter, computer experience, CAI experience, and his opinion of CAI. The information obtained forms the basis of the user profile given in the following section.

Each potential participant was given a written test (pretest). The test consisted of 50 multiple choice questions on course content, to provide a quantitative indication of the student's prior knowledge. The test was developed at the Department of National Defence. Because it is used on a continuing basis by that department and because it will be used again as part of the project, the test is not included with this report.

Once the student completed the pre-test and the first questionnaire, he was given an introduction to system operation and basic operations: installation of the slide carrousel, system entry and exit procedures, overall course organization, and answer entry methods (keyboard or touch-controlled screen).

The preliminary meeting also covered general organization of work sessions at the terminal: expected frequency of use, most suitable times of the week, etc. Participants were told that assistance was available for dealing with problems related to system operation or to understanding concepts discussed in the course. Assistance was to be provided by a section technician familiar with course content, as well as the person responsible for assessment. The offices of both were located near the classroom.

2.4 User Profile

The seven participating employees, two women and five men, were from the following divisions: Division of Electrical Engineering (two employees), Division of Mechanical Engineering, Division of Biological Sciences (two employees), Herzberg Institute of Astrophysics, and the National Aeronautical Establishment. All occupy permanent positions (full time); seniority ranges from 1 to 25 years (1, 2, 10, 16 (2 employees), 23, and 25). Five employees are technicians (repair, maintenance, and equipment modification); two are members of the scientific staff (physics and systems programming).

Table 1 provides a brief description of the student group. The user profile makes it easier to interpret and understand the information presented earlier.

As the first column of the table shows, six of the seven participating employees had some experience in computer use. Most of the experience was work-related, primarily to the use of job-related programs, e.g., computation and data analysis. Three of the employees work in programming, and one of these also tests and repairs computer equipment.

As we said earlier, the course deals mainly with hardware concepts, as well as a few basic software concepts. A student's familiarity with the subject is directly related to any previous courses he may have followed. Because no prerequisites were set by the authors, no trial period selection criteria were based on prior knowledge.

Table 1. User Profile

Student*	Experience related to to computer work in the workplace	Knowledge directly related to subject matter of course	Motivation to follow course	Experience with CAL	Initial attitude
A.	Some experience: use of the computer for computation	Software fundamentals	To acquire new knowledge on computers and find out how a CAL course works	No experience	Favourable: " ... am fascinated to find out how it works ... "
B.	Considerable experience with computer programming	Fundamentals related to hardware High degree of familiarity with software	To acquire further knowledge, more specifically to hardware	Some experience: Has passed a training test as part of a course	Favourable: "I find computer assisted courses quite helpful as a learning tool."
C.	Some experience in programming	Fundamentals of computers and some programming language	To acquire new knowledge that will enable him to work with a new computer system	No experience	Favourable: "If the course is well prepared and presented, ... , I can see no reason why this system would not be beneficial to an individual."
D.	Some experience: use of a computer for computation	No prior knowledge	To acquire general knowledge	No experience	Favourable: "I think the method will be fine (OK)."
E.	Some experience: use of a computer for data gathering and analysis	Fundamentals of electronics	To acquire general knowledge	No experience	Favourable: "I feel positive about the idea."
F.	No experience	No prior knowledge	To acquire general knowledge	No experience	Favourable
G.	Considerable experience: repair and testing of hardware	High degree of familiarity with computer, electronics and programming	To review and update understanding of fundamental concepts	No experience	Favourable: "I feel that computer assisted instruction is very useful."

* For purposes of the report, students are designated by the letters A to G. Except where otherwise indicated, the order of the students varies from one table or figure to another to ensure employee anonymity.

Employee participation was based on personal motivation to acquire new knowledge about computers. All obviously agreed with the participant who said that the course would be of benefit to everyone because computers are everywhere.

Although most students had no direct prior knowledge of CAL, the comments given in part C of questionnaire 1 show a favourable initial attitude; the fact that participation was voluntary confirms this. Several participants saw the fact of being able to progress at their own speed as an advantage; some expressed a few reservations. The comments quoted below illustrate initial participant attitudes.

> I feel that computer assisted instruction is very useful as it allows the student to work at his/her own pace on their own but can also seek more explanations from an instructor regarding topics which are not clear. It is important that the computer assisted instructions are clear and user friendly.
>
> CAL may be less tiresome than reading a text, though not necessarily replacing it.
>
> Working alone with a machine can be irritating unless there are people readily accessible to help and inform the student(s).

Two employees, of whom one had some prior CAL experience and the other had used a computer in school, made the following points:

> I find computer assisted courses quite helpful as a learning tool. The great advantage is that a student can pace herself/himself according to her/his learning abilities. Also, the scheduling of the sessions can be tailored to the student. The disadvantage, on the other hand, lies in the fact is that there no human interaction. No one is there to answer very specific questions!.
>
> If the course is well prepared and presented, and the computer available without the pressure of other students waiting in line, I can see no reason why this system would not be beneficial to an individual.

One employee expressed his interest and curiosity concerning the use of the method:

> I have no experience whatever at Computer Assisted Instruction but am fascinated to find out how it works, especially for one who is far removed from the the formal learning of school and university. The possibility of working at one's own pace is particularly appealing but I am curious to find out how the absence of class-room competition, and the stimulus which this can provide, affects the learning process.

2.5 Hands-on Training Session Organization

During the first few weeks, two training sessions per day per terminal (see Fig. 3) were established. Other than this, no special timetable was set. As time went on, each employee established an individual timetable on the basis of the workload associated with his position.

WEEK OF APRIL 15-19

MONDAY 15	TUESDAY 16	WEDNESDAY 17	THURSDAY 18	FRIDAY 19
	D.	A.	F.	E.
		A.		E.

Terminal 1

MONDAY 15	TUESDAY 16	WEDNESDAY 17	THURSDAY 18	FRIDAY 19
	F.	C.	D.	F.
B.		C.		B.

Terminal 2

Figure 3. Typical weekly schedule

Some participants preferred to devote an entire day each week (e.g., every Wednesday, every Friday), to the training. Others chose a schedule of two or three half-days per week, either because they found it difficult to concentrate at the terminal for a full day or because of personal preference. To allow flexibility to employees whose workload varied from week to week, a few half-days were left free. These sessions were also available to students who wanted additional sessions.

2.6 Methodology

The working method used was based on a broad concept of assessment using case studies and field trials. To quote Cardinet, "This implies that the participant's subjective viewpoint and perception of his situation be accepted as valid subjects of study (9)."

For this reason, most of the techniques and tools selected for the study provide individual participant opinion and reaction. Figure 4 illustrates the methodology used, specifying the times at which the various tools and techniques were used.

We mentioned a preliminary questionnaire completed by each participant before beginning the course, in addition to the pretest. The questionnaire was used to provide the information given in Section 2.4; it deals with participant knowledge, experience, and initial attitude.

After completing the course, the students were asked to pass the test again (post-test) to check on whether or not they had learned anything from the course. Results of the pre-test and post-test are discussed in Section 3.2.

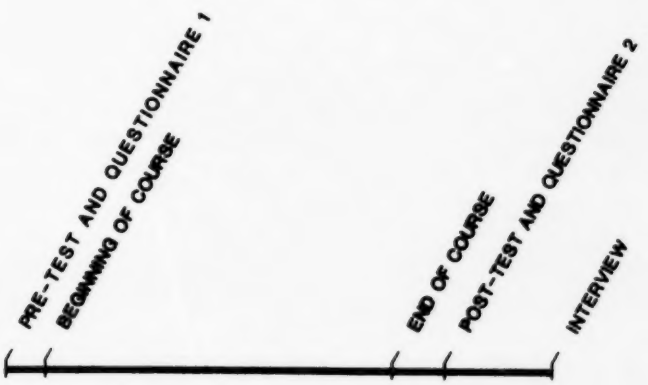

Figure 4. Methodology outline

A second questionnaire was designed to determine participant reaction to and opinion of the experience, and opinion on introduction of similar training systems in the workplace. The questionnaire consists of 10 open-ended questions; they are listed in Appendix D.

Following this, semi-directed individual interviews were held to provide participants with an opportunity to make comments and add to the answers they gave to questionnaire 2, and to discuss the experience as a whole. Four of the interviews were taped to provide an accurate record of the comments made.

Throughout the test period, the person responsible for assessment assumed the participating observer role described by Cardinet (9). This role involves more intervention and cooperation than for a mere outside observer. This does not mean being with the students at all times. It does mean making sure that everything is progressing as it should, and listening to the students' problems, needs, or comments on specific aspects of the situation. The participating observer often acted as an intermediary between the student and the person designated as technical and course content assistant, who could usually pinpoint the problem.

3. RESULTS

3.1 Time Use Profile

Figure 5 shows the time period and total number of hours spent on the course per student. Total number of hours was estimated from a compilation of individual student progress files which contain date and time of each session. Estimates include practice in the mini-lab and various breaks: coffee breaks, discussion and consultation, computer downtime (except when in excess of one-half hour), and technical problems.

The first thing to note is the wide range of time spent on the course per student (between 6 and 17 weeks, for a total number of hours ranging from 41 to 104). The figure also shows that most students preferred to follow the course without interruption (i.e., number of weeks the course being given part-time), with the exception of one or two week breaks for annual leave (shaded area).

Our original estimate of the time required to complete the course (100 h) was confirmed in three cases. All three of these employees had little or no prior knowledge of the course content. The differences in the time taken by each student to complete the course are of considerable importance in assessing the educational and logistic benefits of this type of training system. The use profile is discussed further in the section on merits and advantages.

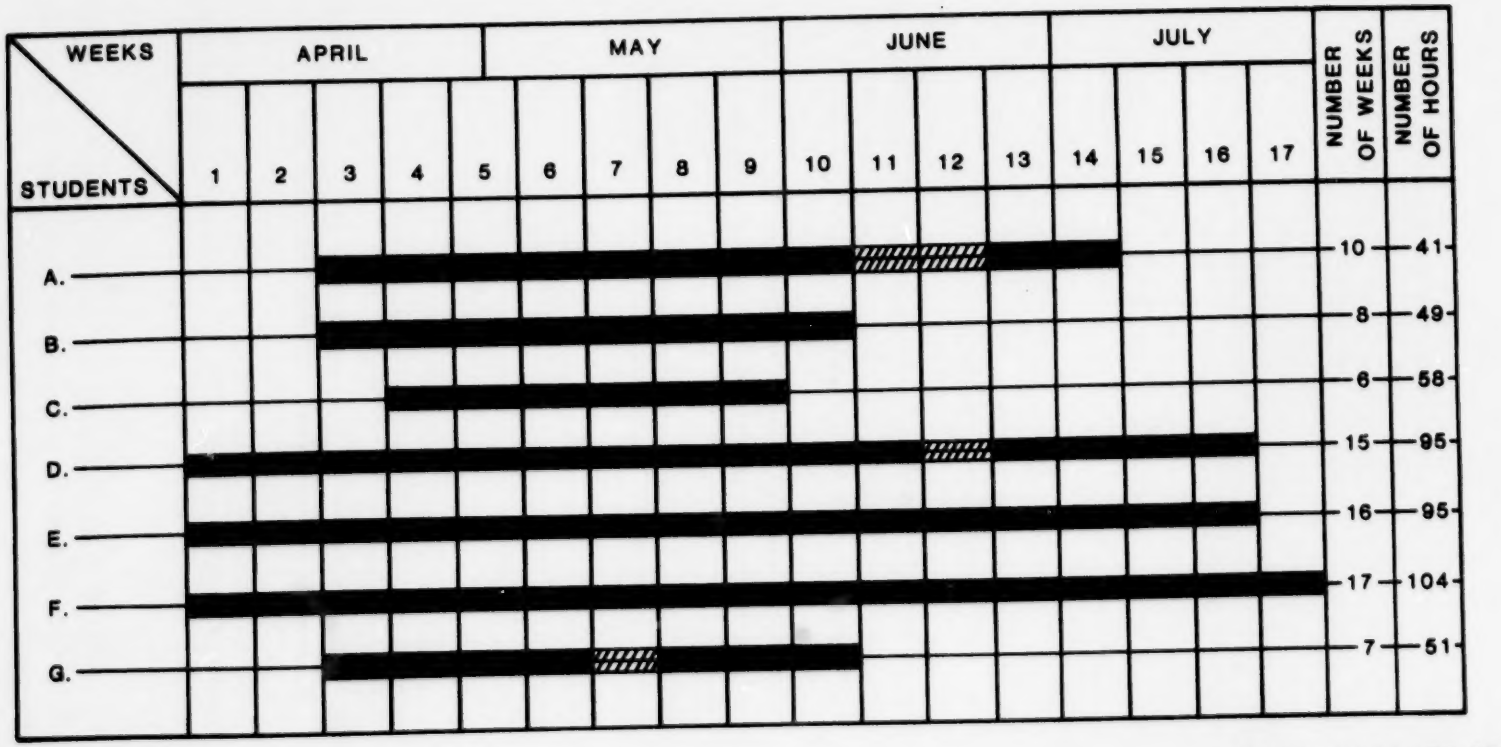

Figure 5. Use profile

3.2 Skills Acquired

The scores in the pre-test and post-test (maximum = 100) are shown in Table 2.

Table 2. Comparison of pre-test and post-test results

Pre-test %	Post-test %	Difference between pre-test and post-test
10	60	+50
18	78	+60
26	88	+62
38	74	+36
60	92	+32
62	80	+18
84	94	+10

The results are illustrated in Fig. 6, a comparative diagram. It indicates that the post-test results of all students were in the upper half of the scale. Most were in the lower half in the pre-test.

Table 3 gives the mean, standard deviation, median, and interquartile range of the results obtained on the pre-test and the post-test.

Table 3. Mean, standard deviation, median and interquartile range of results obtained on pre-test and post-test

	Pre-test	Post-test
Mean	42.6	80.9
Standard deviation	26.9	11.8
Median	38	80
Interquartile range	39	14

Figure 7 uses two bar graphs to illustrate the median tendency and dispersion tendency (1st and 3rd quartiles) of the pre-test and post-test.

Because of the limited number of students, care must be taken in interpreting the statistics and diagrams. They are as yet only tendencies, which will be confirmed or disproved by data currently being gathered in the continuation of the project.

Nevertheless, the results indicate that the students made substantial progress (the Walsh (11) test was significant, $\alpha = 0.01$) in content assimilation between the pre-test and the post-test.

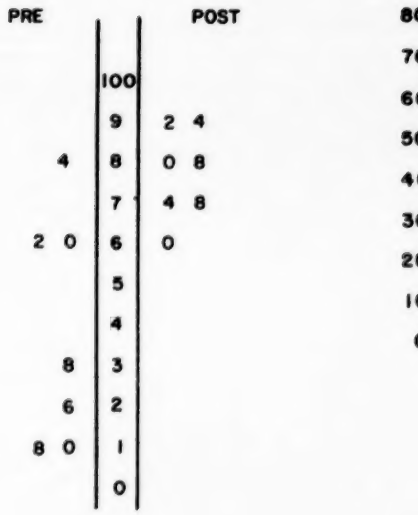

Figure 6. Comparative diagram of pre-test and post-test results.

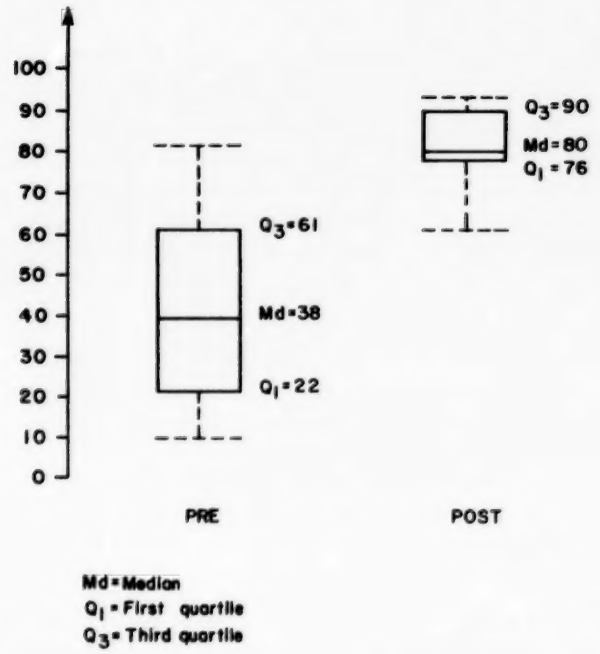

Figure 7. Bar graph of median results and range (1st and 3rd quartiles).

3.3 Student Feedback

The purpose of this section is to discuss the students' replies to the questionnaire they were given at the end of the course. The 10 open-ended questions included are given in Appendix D.

The questions deal with three main subjects, which are treated in the following subsections. They cover

- student satisfaction with skills acquired, and course relevance
- aspects of CAL or of the experience as a whole that are the most appreciated; advantages of CAL for training (or retraining) at NRCC
- aspects of CAL or of the experience as a whole identified as shortcomings or disadvantages

Several of the opinions and comments expressed in the interviews are quoted in full to provide additional information.

3.3.1 Student Satisfaction with Skills Acquired and Course Relevance

The comparison of test results given in the preceding section provides an important indication of skills acquired. Nonetheless, student opinion and reaction to the knowledge acquired in the course is the best gauge of project success and relevance to the specific workplace.

Figures 8 and 9 give student answers to questions 1 and 3, on the subject of satisfaction with and opinion of the course's relevance to their work. For these two questions, the comments are presented in the same order so that they correspond to the same participant. The first comment quoted for question 1 is incomplete, because the student added several observations on the course itself. These will be taken into consideration in the section on course shortcomings.

The first thing to emerge is that all participants are satisfied with the learning experience and consider course content relevant to their regular work with NRCC.

The comments of two participants show some disappointment. One wanted more information on how to operate specific computers and on procedures for interacting with them. A second (who had considerable prior knowledge of content) would have liked more detail on such aspects as microcomputer troubleshooting techniques. Both students did stress the benefits of the course, both in breaking new ground and updating prior skills. This is of particular interest because it shows that a system of this type can respond to different types of motivation.

Another interesting factor is the relationship between significance perceived and employee's regular type of work. For example, familiarity with hardware has no direct application to the work of a programmer. It does give the programmer a better understanding of the work of his colleagues and the implications of his own work.

That said, it is safe to state that most of the concepts covered in the course, especially those related to hardware, are closely related to the current (five participants) or future (two participants) work of the participants.

It is obvious that experience of this type could be extremely beneficial to a large number of NRCC laboratory employees. When the letter of invitation was sent out, some reticence was expected from directors and supervisors. The course does, after all, require an employee to devote several hours per week to it over a relatively long period (original estimate of three months). We did not really expect more than five or six applications.

ARE YOU SATISFIED WITH WHAT YOU HAVE LEARNED?

"On the whole, I am satisfied ... it introduced me to an entirely new aspect of computers as I had only dealt with the programming side until now"

"I am quite satisfied. The course enabled me to relate hardware and software concepts to each other. I did not feel confident with hardware terminology, now at least, I have some idea of the meaning of hardware key terms."

"Yes. I have come away with new knowledge and a better understanding of computers, the course has also refreshed my memory in certain areas."

"Yes."

"Yes, but I expected to get more of the actual sitting down at the terminal and the commands for transferring material and making files ... [to get more about] what most particular computers did."

"Yes."

"I am satisfied with what I have learned but felt it could have gone a bit more in detail in some subjects for myself."

Figure 8. Student comments (question 1).

WAS THE CONTENT OF THE COURSE RELEVANT TO YOUR PROFESSIONAL ACTIVITIES?

"It has some relevance to my activities ... where we are involved in computing on main-frame, mini and micro-computer. However, perhaps the greatest advantage will be in dealing with problems in my home computer where there are no electronics experts at hand to help!."

"Yes, I believe so. Since I work with both hardware and software people, I will be able to relate these two aspects of computer to each other. I still don't understand everything but now I know what to ask."

"The contents touched some immediate areas of concern. I was initially encouraged to participate in this course for future involvement in a newly acquired computer system."

"... to some of my work. Maybe more in the future."

"Yes. Most of it was along the line of what we have."

"Only part. We use computers [at work] ... quite often, people ask me to do something when they are not there, so I should know what's going on."

"Yes, it was relevant to my professional activities."

Figure 9. Student comments (question 3).

The fact that 30 applications for the course were received demonstrates the need for employee training in the new technology. The comment of one student on the advantages of such a course sums it up nicely. To quote, "I believe that it is a good idea for anyone who is interested in learning about computers or for anyone who deals with any form of automation to take an introductory course such as this one. Although some concepts might be hard to understand at least the person would have some idea of how a computer works. And this is very important in our day and age when computers are being used in so many fields of work."

The participating employees also demonstrated their satisfaction with the course by recommending it to colleagues. This positive attitude emerges from the answers to question 6 (Fig. 10). Despite the fact that most answers deal specifically with content, the positive attitude is implicitly linked to CAL as a concept.

The preceding statement is every bit as valid for participant interest in other CAL courses. Following this introduction to CAL in the workplace, all participants expressed interest in a further CAL course, especially if the content is job-related. The areas of interest mentioned by the participants in answer to question 7, "Would you be interested in taking another course of this type? If so, what subjects would be of particular interest to you?", are

- programming

- operation of specific computers

WOULD YOU RECOMMEND TO COLLEAGUES THAT THEY TAKE SUCH A COURSE?

"I would certainly recommend to colleagues that if the need and the opportunity arise for them to take such a course, they should do so."

"Yes."

"Most of my colleagues at the moment are quite knowledgeable in the field of computers. However, if I knew some people that were interested in learning about them, I would certainly recommend this course."

"Yes. I wouldn't consider that it was a waste of time."

"Yes, I think this system is an interesting way to introduce new subject matter to co-workers; expecially if the employee is hesitant of working with computers."

"I would recommend it to those who had little knowledge of logic circuits and microcomputers."

Figure 10. Students comments (question 6).

- operation, architecture, and design of micro- and mini-computers

- how to interface peripheral equipment and various measuring instruments

- electronics and instrumentation

- system management, performance, and security

One employee commented at the interview, "You should be able to upgrade your skills ... being in a job that I'm in, you have to upgrade ... everything is always changing. You work on newer and newer things." The broad variety of subjects of interest to the seven participants and their positive attitude to the course's relevance suggest that other CAL courses would be appropriate for meeting the training needs of employees in this work environment.

3.3.2 Merits and Advantages

The first and most obvious conclusion to be drawn from the foregoing is that the learning experience was perceived as both enriching and relevant. Obviously CAL is not the only option open to an employee interested in acquiring new knowledge or upgrading existing skills. The comments and reactions of participants suggest that CAL does have important advantages over other training systems for use in the workplace.

Questionnaire 2 contains two questions that deal specifically with these points. Question 4 asks "What aspects of your experience did you like the most?". Question 8 asks, "What advantages do you see in the use of such courses to train NRCC personnel?" The answers to question 4 are given in Fig. 11.

Student comments made in answer to question 4, and in the interviews, show a positive attitude to three aspects of the course. The first is fundamental CAL strategy, i.e., the personalized teaching that allows each individual to progress at his own speed. The second is the flexible timetables. The third is the technical and educational assistance available.

To five participants, the ability to work and progress at one's own pace is one of CAL's greatest merits. At the interviews, all five said they liked this aspect of the training system very much. Section 3.1 shows the differences observed in time taken to complete the course. The broad range indicates that each individual did go at his own pace, as determined by prior knowledge, individual ability and number of hours available per week. Generally speaking, those who had little or no prior knowledge took longer

WHAT ASPECTS OF YOUR EXPERIENCE DID YOU LIKE THE MOST?

"I liked the fact that I was able to work at my own pace. I was able to move back and forth through the course as I pleased. I was also happy to have someone that could help me if I had some trouble with certain parts of the course."

"Flexible hours for the course; quiet surrounding (only 2 people per room); technical help was always available (when computer failed to function)."

"Answering questions successfully, indicating that an explanation was understood; gaining an overall view of the subject of computers."

"I liked being able to set my own pace depending on the material."

"I enjoyed the challenge of a new learning experience, especially having been at the teaching end since graduation ... . It was fascinating to discover how courses of this kind are presented, to work at one's own pace rather than at the pace of a class, and to emerge with a feeling of some accomplishment."

"I enjoyed the practical experiments and the hands on experience on test equipment. I liked being able to go at my own pace."

"I find this method of learning relaxing where one can work at his or her own pace, with the option of reviewing your material without holding up a class or facing behind. I enjoyed the practical lab aspect where theory and hands on experience come together, working with examples off the screen or slide display also clarifies the theory previously presented."

Figure 11. Students comments (question 4).

to complete the course. Those familiar with the course content went faster. Comparing the method to conventional group teaching, one of the students commented (at the interview):

> You are not limited by the speed of the class. If you find something very easy to comprehend or easy to go through, you can go through quicker than you can in a classroom when you have to wait for anybody else to catch up and to understand it. Since through the other way, if there's something that you don't understand you can take your time going through it and trying to understand it rather than to have to be rushed in a class. So, going this way, you get to go at your own speed.

Participants also liked the provisions for note taking, review, and breaks as needed, i.e., the personalized procedure adaptable to individual preferences and needs. They did not entirely discount the idea of group teaching. They did express a preference for the training strategy followed (with some reservations discussed in the following section), especially one that can be integrated into the regular work schedule.

Personalized instruction allows for a flexible schedule. The participants were most favourable to this logistic aspect and it caused no terminal

use organization or planning problems. Even though only two terminals were available for seven participants, all seven were able to select sessions according to personal preference. At the interviews, the employees said they had not found the course too long, specifically because of the part-time aspect. One participant said, for example, "I did not find the course too long, ... partly because of the flexible hours, we can come when we get time, we can fill in on extra days."

The initial phase did not involve comparison between part-time operation and full-time operation. It was interesting nonetheless to discuss the subject with the employees. Six out of seven stated a preference for part-time operation. Their main reason was that it gave them a chance to let the subject matter sink in (to think about it, to review notes). More important, it is often difficult to be away from the job for several weeks running. As long as the terminal/participant ratio is adquate, CAL can make allowances for the employees' personal preferences.

Another aspect of the experience that was liked was the availability of assistance. In this environment, it was considered to be virtually a pre-condition for using CAL.

The students asked for technical assistance with hardware and system operation problems. There were no major hardware problems during the trial period. Several drawbacks were noted repeatedly. Students were very tolerant in accepting the drawbacks as an integral part of the situation. However, activities were repeatedly interrupted because of them. During the first few weeks of the course, static electricity produced by a carpet in the classroom and the room's insufficient humidity caused frequent terminal down time. The situation was remedied by installing a humidifier. Later, during the summer, the problem was far less frequent because the air conditioning was on. Handling the slide projection system regularly locked the terminal. Before beginning entry procedure, the student must install one of two slide carrousels (depending on where he is in the course). Sometimes the student forgot, or inserted the wrong carrousel. The computer did not recognize the situation, accepted the entry procedure and the session proceeded normally until it was time for the first slide. At this point the student realized that there was no slide or that the wrong one was being shown. When this happens, the only solution is to exit from the program, re-enter it, and return to the appropriate spot. This type of technical problem requires a resource person familiar with the hardware to carry out the operations necessary to reboot the system. This whole procedure is time wasting. Worse still, a lockout wipes out the computer memory beginning with the last entry and the student has to start over (at the beginning of a lesson for example), unless the resource person can change the data in the computerized student register.

Assistance also proved necessary to solve problems related to content comprehension. No additional resources (modules or branches containing additional explanation; related teaching material) were available for the chapter generally considered the most difficult. Every student had to ask for assistance with this chapter at least once.

Participants also were satisfied with the practical aspects of the course, more specifically the hands-on mini-lab. They also liked the calm, relaxed atmosphere; the classroom was not used for any other purpose during this time. Two students also mentioned the importance of being able to regulate the lighting at will. The employees who took the course in half-day sessions did not find any serious disadvantage in having to travel from the workplace for the course. They did stress the fact that having a terminal at the division where they work avoids loss of time due to travelling, and facilitates more frequent access to the terminal (half an hour, an hour). Four employees stressed the importance of a room being set aside for the course, one not in the regular workplace, a place where it was possible to concentrate exclusively on the course and where assistance was readily available.

The answers given to question 8 on the advantages seen (shown in Fig. 12) provide a summary of the information given above. The following

WHAT ADVANTAGES DO YOU SEE IN THE USE OF SUCH COURSES TO TRAIN NRC PERSONNEL?

"General overview and knowledge of areas where our work may take us. Such as knowing key buzz words relating to computers or electronics since these areas affect us in just about any career field."

"It would upgrade their technical knowledge and teach them new subjects to help them further their careers in the council."

"These courses have great advantages over conventional classroom courses in that they are available at any time to any number of students and each student can work at his or her own pace, regardless of the progress of the others."

"A course like this can be completed and not interfere too much with one's regular work."

"Courses should be designed to further train personnel in the direction that their activities may take; these courses can be integrated into one's work schedule."

"Courses during work hours are a good idea."

"I believe that it is a good idea for anyone who is interested in learning about computers or for anyone who deals with any form of automation to take an introductory course such as this one. Although some concepts might be hard to understand at least the person would have some idea of how a computer works. And this very important in our day and age when computers are being used in so many fields of work."

Figure 12. Student comments (question 8).

is a summary of the main advantages of using a computer assisted course, as seen by the participants:

- this type of course offers the employee the opportunity to acquire or update work-related knowledge;
- this type of course may easily be integrated into the employee's regular work schedule;
- the employee can work at his own speed.

3.3.3 Shortcomings and Disadvantages

In our discussion of the study's aims, we explained that our purpose is not to evaluate the course itself; this has already been done. During the trial period, participants ran into difficulties specifically related to the course, difficulties that must be dealt with before systems of this type are developed and introduced for training of other NRCC employees. For this reason we will discuss the negative aspects mentioned by participants, insofar as they are relevant to evaluation of basic CAL strategy.

The main sources of information for this subsection are questions 2, 5, and 9 of the second questionnaire, and regular observation of and contact with participants. This allows us to assess the relative importance and implications of the disadvantages. Figures 13 and 14 show the comments given in response to questions 2 and 5.

It is interesting to note that all students found it relatively easy to learn to use the system. At the interviews, several noted that the absence of complicated operations, the interactiveness of the system and being able to operate on an individual basis were aspects that contributed to the learning situation's interest. The problems encountered are related to presentation of the material, not to the fundamentals of CAL (interactivity, feedback), which was considered an advantage by participants. The hardware was not seen as a problem in itself, although there were difficulties in operating the computer and the slide projection system. Only one student mentioned that the touch controlled screens were somewhat frustrating; the computer sometimes did not "understand" the spot pointed to correctly. An employee who was afraid that having to use a keyboard would slow him down, actually had no problem with it at all. We can safely say that no major negative aspect, either logistical or related to general application of the system in this working environment, was raised by any participant. For this reason, project conditions (described in detail in Section 2) are of crucial importance in assessing this type of training system.

BASED ON YOUR EXPERIENCE, IS IT RELATIVELY EASY OR DIFFICULT TO LEARN BY THIS METHOD?

"Relatively easy most of the time."

"This method of learning seems to be fairly easy. This depends on how the material is presented. ... Some basic problems in presenting this course were: 1) the inability to go back over some part of the material at any time; 2) the inability to exit the program when one gets stuck. For some of the above reasons I feel that an instructor should be available."

"I found it relatively easy to learn by this method. You can go at your own pace. ... As long as the program is clear enough and you can understand, I find there's no problem to go through it. You have to look at it as a tool to help you. You control the computer."

"I found this learning experience to be relatively easy on the whole."

"Some parts of the course I found relatively difficult to learn by this method."

"It was relatively easy to learn by this method but I would like to make two reservations:

1. The absence of a textbook means that the students have nowhere to turn to have questions answered or problems explained. Lesson and chapter tests determine whether or not a student has understood but not why she or he has not understood the material covered. Mere repetition of a particular lesson or chapter does not necessarily increase the understanding and in this case supplementary material such as textbook would be useful.

2. The results of the tests simply indicate a pass or fail and it was impossible to discover where the mistakes and the weak points lay. Conventional courses invariably offer some kind of a post-mortem and I wonder if a Computer Assisted Course could not be designed to give similar service to the students."

"I found it relatively easy to learn in this way. However, I did have experience with computers and many concepts of the course (mostly software) were familiar to me. On the other hand the hardware concepts were a little newer to me and I had a little trouble with these. It was a good idea to have someone on hand that could explain things to me a little more in depth. ... You can compare it from a book where there is examples and exercises ... also able to answer interactively and have a feedback."

Figure 13. Student comments (question 2).

Three shortcomings emerged from participant response to the questions on negative aspects of the system.

One shortcoming was that the system does not allow for exit at will. The program allows for exit through a special command repeated every four or five pages; this gives the user relatively broad control. However, during the course's simulations and practical exercises the exit command is not available; an exercise must be successfully completed before the user can have access to any other command.

WHAT ASPECTS OF YOUR EXPERIENCE DID YOU LIKE THE LEAST?

"... a few aspects of the course that I did like are the following: not being able to exit from the course easily or instantly by say typing in a special character; not being able to see the answer of chapter tests; chapter 2 was a bit too long and maybe should be split up; the type of answers required for quizzes might be more specific; the grading "weak" might be changed to something more encouraging."

"I found the practical labs dull and, in the beginning, irrelevant with no obvious relation to the rest of the course. The trouble-shooting was more interesting but it was enormously frustrating because I felt that I had no real understanding of what was going on nor of what was really required. ... One very personal point is that I found the "well done!", "you've got it!", "right on!" and similar exclamations childish, irritating and unnecessary."

"I think the student should have the control to back up the computer to previous pages at any time; I think the student should be able ... to stop at any time he chooses."

"I did not really have any bad experiences. I believe some updating on the system should be done, such as: availability of hard copies of lessons as well as copies of questions from the lesson and chapter tests."

"I wish you were able to see what question you spot wrong on the test and see that the proper answer was."

"Not being able to answer questions and not being able to exit; feeling that the material presented was not enough to answer some questions."

"Being forced to answer questions in the review mode while trying to find one bit of detail (no fast research)."

Figure 14. Student comments (question 5).

This was seen as a shortcoming in that it forced a student who could not successfully complete an exercise to end the work session "under pressure", to leave asking the resource person to carry out the necessary closing operations (if the employee wished to leave), or to ask for assistance in completing the exercise. In this case, the student would have preferred to review the material and try the exercise again; this option was not available. This shortcoming, which was mentioned by several participants, shows the importance to the adult student of being in relative control of interaction with the computer. This aspect is also mentioned in comments on the impossibility of accessing all preceding pages through use of a single command, and the fact of having to answer all the questions again or to redo all the exercises when reviewing material. It would appear in this case that the option of an appropriate review mode would be welcome. This would avoid loss of time for the student who is looking for a single piece of information in a specific lesson.

A further shortcoming is the inability to find the correct answers to questions missed. Participant observation confirms the comments made by the students in response to questions 2 and 5. This was seen as more important where a student was trying to pass a test for the second or third time, but did not know which questions he was answering incorrectly. The main reasons for the situation were spelling mistakes in the answer; these were read as errors. Another source of error was the lack of exact instructions on response entry methods (e.g., putting commas between each word). To find the reason for repeated failure of a test required calling the assistant, who then consulted the program.

A third important aspect to be considered is the fact that, in the absence of written documentation or worksheets, the student was obliged to take many notes if he wanted to refer to preceding concepts without leaving the page on the screen, or if he wished to keep a record for later reference, once the course was finished. The lack of additional explanation module branching is another reason course-related documents are required. Instructor assistance is effective in answering questions related to content.

The answers given to question 9 (Fig. 15) show that the majority of participating employees see no disadvantages in the use of CAL at NRCC. Comments made by three respondents on the possible disadvantages discussed above should nevertheless be taken into account. The second answer quoted

DO YOU SEE ANY DISADVANTAGES IN THE USE OF SUCH COURSES TO TRAIN NRC PERSONNEL?

"No."

"Too much time could be spent on unrelated material."

"No."

"I see no real disadvantages, though some individuals may find it an impersonal way to learn."

"No."

"One disadvantage might be that not all subjects (and possibly not all students) may lend themselves to this type of training; care would have to be exercised in the selection of courses offered and in the selection of the students. There may also be a danger in allowing students to work entirely at their own pace without some monitoring of their progress. I also question whether a computer assisted course on its own, without textbooks and supplementary material, is sufficient."

"No, I don't see any."

Figure 15. Student comments (question 9).

suggests that fairly accurate descriptions of courses offered (and perhaps of the estimated time for covering each chapter) be provided; another option is the use of tests accompanied by appropriate branching for each user. The second and third comments reflect an opinion that this type of course is probably not suitable for everyone. Continued assessment of this point would be relevant in the application of CAL systems.

4. CONCLUSION

Can computer assisted instruction make a worthwhile and interesting contribution to the training (or upgrading of skills) of NRCC employees? We make no claims to have a complete, definitive answer to the question. However the experiment described in this report certainly suggests an affirmative answer to the question and supports the introduction and application of a CAL system at NRCC.

Comparison of pre-test and post-test results clearly show that participants made substantial progress in their understanding of course content. Participants expressed relatively high satisfaction with the learning experience, which they perceived as relevant to their professional activities.

If a person's attitude to something is defined as his predisposition to become motivated in his relationship with it (12), there is no doubt whatever that participant motivation to follow other CAL courses is proof of their favourable attitude toward this type of training system. Our aim was not to provide a systematic, in-depth study of the learner-medium relationship. We are able to say, however, that all participants accept basic CAL strategy, and report no major problems related to its use. This is extremely encouraging.

The conditions under which the project was carried out, and their impact on its success, remain to be considered. The most important of these are flexible timetable, time period allowed for completion of the course, and availability of easily accessible assistance. Assessment project follow-up will undoubtedly lead to exploration of other methods of CAL at NRCC. The importance of these factors on the first trial period suggest that they will remain the basis for the success of further applications of this type of training system at NRCC.

ACKNOWLEDGMENTS

The project described in this report was made possible by the close co-operation of a number of key participants.

We would like to express our thanks to Jack Brahan, Head of the Information Science Section, and to Yves Bégin, professor/researcher with INRS-Education, for entrusting us with a fascinating project, and for their ongoing assistance and support.

Sincere thanks to the seven employees who were the project's students. They were exceptionally cooperative in providing information requested. We can only hope they gained as much from the experience as they put into it.

We would also like to thank Reg Shevel, our project resource person in the Information Science Section, for making himself available whenever he was needed, and Richard Bertrand, professor/researcher at INRS-Education, for his help in preparing the statistical tables.

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APPENDIX A

APPENDIX B

LETTER OF INVITATION; DIVISIONS TO WHICH LETTER SENT

26 March 1985
26 mars 1985

In collaboration with the Institut National de la Recherche Scientifique of the University of Quebec (INRS - Education), the Division of Electrical Engineering is carrying out an evaluation of Computer-Assisted Learning as applied in environments such as we have here at NRC. The effectiveness and limitations of CAL have been studied in structured settings (schools, colleges, military, etc.) but little information is available relevent to its integration in the less structured training environments (industry, government, etc.) where the motivation is the acquisition of new skills, not a "credit" for course completion and where there are often interfering demands on the student's time. Thus the objective of the investigation is an assessment of the CAL system and identification of parameters that are important in this setting. Neither the courses, nor the participating students will be the subject of the evaluation. The courses to be used have been validated elsewhere and have been selected on the basis that they offer a means of acquiring skills of value to NRC staff.

En collaboration avec l'Institut national de la recherche scientifique de l'Université du Québec (INRS - Éducation), la Division de génie électrique procède à l'évaluation de l'enseignement assisté par ordinateur (EAO) tel qu'appliqué dans le genre d'environnement que l'on retrouve ici au CNRC. L'efficacité et les limitations de l'AEO ont été étudiées dans des cadres structurés (écoles, collèges, établissements militaires, etc.) mais peu d'informations sont disponibles quant à l'intégration de l'EAO dans des milieux de formation moins structurés (industrie, gouvernement, etc.) où le facteur motivant est l'acquisition de nouvelles habiletés plutôt que l'obtention d'un "crédit" pour avoir complété un cours. L'objet de cette enquête est donc d'évaluer le système d'EAO et d'identifier les paramètres qui sont importants dans ce genre de milieu. Ni les cours, ni les participants ne feront l'objet de cette évaluation. Les cours qui seront utilisés ont été validés ailleurs et ont été choisis parce qu'ils offrent un moyen d'acquérir des habiletés d'une grande utilité pour le personnel du CNRC.

.../2

The initial course that has been selected for use in the evaluation is one in DIGITAL COMPUTER FUNDAMENTALS that was originally developed for training of maintenance technicians within the Department of National Defence. The content of the course is summarized in the attached outline.

We are looking for volunteers who could benefit from this course and who, from now to 30 June would undertake to devote approximately 100 hours (in full or half day sessions) to taking the course and to subsequently answering a questionnaire.

A pretest and a post-test on the course content will be given to each of the participants, but this information is intended only for purposes of evaluation of the CAL system, not the participant. Individuals will be informed of the results of these tests, but their names will not be associated with the recorded data.

I would be grateful if you could inform your staff of this experiment and grant permission to those who wish to participate to devote the required time. Potential participants should contact Jack Brahan at 3-2484.

Le premier cours qui a été choisi pour servir à l'évaluation porte sur les PRINCIPES FONDAMENTAUX DES ORDINATEURS NUMÉRIQUES qui fut originalement conçu pour la formation des préposés à l'entretien au sein du ministère de la Défense nationale. Le contenu de ce cours est décrit dans le document ci-annexé.

Nous sommes à la recherche de volontaires qui pourraient bénéficier de ce cours et qui seraient disposés à consacrer, d'ici le 30 juin, environ 100 heures de leur temps à ce cours, (en séances d'une journée ou d'une demie journée à la fois) pour ensuite répondre à un questionnaire.

Chaque participant devra subir une épreuve préliminaire et une épreuve terminale portant sur le contenu du cours. L'information recueillie servira uniquement à l'évaluation du système d'EAO, et non à évaluer les participants. Ces derniers seront informés des résultats obtenus aux épreuves, mais aucun nom ne sera associé aux données enregistrées.

Je vous serais reconnaissant de bien vouloir informer votre personnel de cette expérience et d'accorder la permission à ceux qui désirent y participer d'y consa- crer le temps requis. Les parti- cipants éventuels devront commu- niquer avec Jack Brahan au numéro 3-2484.

Le directeur,

J.Y. Wong
Director

JYW:cd

APPENDIX B (Cont'd)

LIST OF DIVISIONS

Division of Building Research

Division of Mechanical Engineering

National Aeronautical Establishment

Division of Chemistry

Herzberg Institute of Astrophysics

Division of Physics

Division of Biological Sciences

Division of Energy

APPENDIX C

QUESTIONNAIRE 1

Student's number:_____

Date:_____

Division:_____ Section:_____

Job description:_____

_____

A) Have you had any experience with computers before? Yes [ ] No [ ]
If yes: hardware [ ] software [ ]

Circle where and describe briefly:
At work:_____

At home:_____

On course:_____

Other:_____

Was it a good experience?

B) The course concerns Digital Computer Fundamentals.

Have you had any previous experience pertaining to this subject?
Yes [ ] No [ ]

If yes, please describe what/where/when:

C) In the space provided below, please state your opinions about Computer assisted instruction.

APPENDIX D

QUESTIONNAIRE 2

1. Are you satisfied with what you have learned?

2. Based on your experience, is it relatively easy or difficult to learn by this method?

3. Was the content of the course relevant to your professional activities?

4. What aspects of your experience did you like the most?

5. What aspects of your experience did you like the least?

6. Would you recommend to colleagues that they take such a course?

7. Would you be interested in taking another course of this type? If so, what subjects would be of particular interest to you?

8. What advantages do you see in the use of such courses to train NRC personnel?

9. DO you see any disadvantages in the use of such courses to train NRC personnel?

10. Do you think that computer assisted training has a future?

11. Other comments.